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ABSTRACT

As an estimate of probability of readability is discussed within the problem of ensuring that science tests meet the purposes of measuring skills, knowledge and ability of students. The necessity of technical terms is cited while arguing that testing for language should not interfere with tests for knowledge and skills. A review of formulas for measuring readability is presented to establish general principles, and several approaches to solutions in readability and testing are discussed. The appendices include a table and a scale for measuring reading ease by Flesch and a summary of findings by Gardner on student understanding of science connecting words. A word list shows percentages of correct usage of science terms in the context indicated. (Author/CM)

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READABILITY AND SCIENCE TESTING

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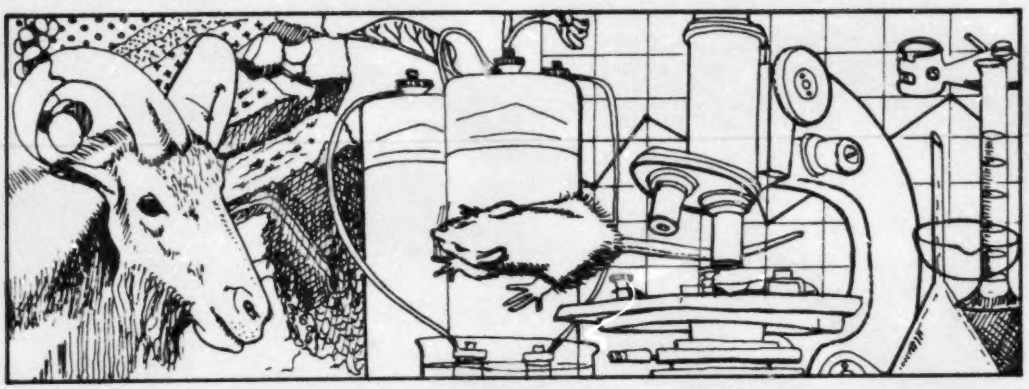

TM 820 305

VOLUME FIVE OF THE SCIENCE LIBRARY OF TEST ITEMS

The Science Library of Test Items is a growing project. This is Volume Five, and two more are in late stages of preparation. The previous volumes and their descriptions are:

Volume One : a collection of multiple choice items.
Volume Two : a second collection of multiple choice items.
Volume Three : Introduction and Manual to Mastery Testing.
Volume Four : The Practical Testing Guide.

All material in the project is made available in the hope that teachers will select those parts which are of use to them in developing their own testing programmes.

READABILITY AND SCIENCE TESTING

School Certificate Development Unit, October 1979.

Since the materials which comprise the S.C.D.U. Science Library of Test Items started appearing, many teachers have complained that the material did not cater for "slow learners". In this context, a "slow learner" seems to be defined as a student who has difficulties in the area(s) of English language and reading comprehension.

Now it is quite obvious that normal tests will not work with a student who can not read, or who can not speak English. This paper is intended to look at the problem, clarify some aspects of the problem, and (very tentatively) suggest some solutions for testing students with limited ability in the area(s) of English language and reading comprehension.

Most science courses include in their aims a statement about developing communication skills such as reading, writing, listening and speaking. The discussion which follows is based on the assumption that we should avoid testing language *when we intend to test science skills, knowledge and ability.* It is NOT based on the assumption that science teachers should not test language, particularly when that language is science - oriented. The writer is a "language across the curriculum" devotee who believes in seeking solutions to classroom problems. The problem to be dealt with here is that of ensuring that "science tests" test science.

ACKNOWLEDGEMENTS:

In the past eighteen months, this document has led me into many byways, and I have obtained comments and advice from many people. So many people, in fact, that any listing would be likely to offend by omission. Let it suffice, therefore, for the patient typing of Alison Adlard, Margaret Ford and Sharon Webb, and the patient proofing of Jan Anglim to be noted.

Any remaining faults are mine and should be drawn to the attention of:

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SYDNEY. 2001.

READABILITY AND HOW TO MEASURE IT

For some years now, teachers have been aware of the problem of readability in text material presented to students. This was stressed by the Australian Science Education Project (ASEP), and it was from ASEP that most NSW science teachers became aware of the question.

Readability is not a measurable physical characteristic like length or mass. It is an *estimate of probability of comprehension* by a particular group. It is essential that this point be kept in mind when various systems of "measuring" readability are discussed.

The usual way in which one hears of readability is at a course, conference or seminar where an informed person asserts knowingly "such and such a newspaper has a reading age of 10.5". This means that, according to one method of estimating readability, an average 10½ year-old could understand the information supplied in that newspaper. Unfortunately, while there are many "scales" which have been developed, none was developed for Australia, and many are approaching thirty years of age. Each scale incorporates a number of assumptions, and in the absence of "hands on" experience, teachers do not encounter these assumptions. The purpose of this section is to remedy that deficiency.

But first, let us consider the problem as it is commonly raised by teachers: to them, readability is a matter of ensuring that material is suitable for "slow learners" (*alias* those of low reading age). They suggest (rightly) that a science test should be a science test. It should test science knowledge, skills, etc., and should not test the ability to comprehend inordinately circumlocuitous prose all set about with fractured syntax.

The intuitive solution is to delete all technical terms from the test questions. The *rationale*, quite obviously, is that the technical terms are usually "big words". As "big words", they may be dismissed as unnecessary jargon, thrown about to impress the unwary. Any fool can see that slow learners do not need them. Of course if one of those slow learners becomes a mechanic and works on his ex-teacher's car, he will be expected to use the right tools! Naturally! "None of this 'do it all with a shifting spanner and screwdriver' stuff on my car thank you very much! I want the proper tools used," says the teacher. But then that's different, isn't it? Isn't it? Technical terms are normally used to convey fine (but important) differences in meaning. Let's not lose sight of that.

A more useful approach might be to look, for the moment, at components rather than vocabulary. To my mind, the best source, and the one I have followed, is Gilliland, and interested readers are referred to this useful book for further detail.

At the risk of stating the obvious, readability must be about *comprehension*: the extent to which the reader understands what he/she has read. Any attempt to improve readability will succeed only as far as it succeeds in enhancing the student's comprehension.

This will depend in large part on two other factors: *fluency* and *interest*. Fluency here means the extent to which the reader can proceed through the text at the optimum rate. Interest is a conglomeration of factors which cover the *motivation* of the student to read the material.

Material of high interest will, of course, tend to have a greater fluency, and also tend to be better understood. And material which is well understood will be more interesting, and by its interest, come to be read faster. And, finally, material of high fluency will be satisfying, satisfaction being one aspect of interest. While these factors may be separated for the purpose of criticising and improving a text, they are not separable in real life.

In addition to the motivational characteristics of the text, there is also the motivation of the reader, and the persistence of the reader. These are individual differences, and their inclusion in any scale of readability is a challenge to the ingenuity of the scale makers.

The questions of type size, type face, and spacing between lines (leading) present more special problems. While the optimum combination may be assessed qualitatively, there appears to have been no work on the *quantitative* assessment of those typographical factors which affect readability.

We come now to the question of the words which appear in the text. Many measures do make some allowance of some sort: hard words may be arbitrarily defined as those "of three or more syllables", or as those "not on the Dale list of 769 easy words" (which includes *afternoon*, *already*, *American*, *animal*, *another* and *anything* in the a's - all with three or more syllables). There is also a Dale list of 3000 words.

The best way of explaining the range of variables thought important is to review the range of estimates in existence, and to examine the parameters included in these estimates. It should be noted that formulae work either by:

(i) adding and/or subtracting measurements taken on a sample, usually after multiplying the measurements by loading factors; or by

(ii) using the sample measurements to enter a table or graph to come up with a number.

In either case, the number is of one of two sorts:

(i) an index number for comparison purposes; or

(ii) the reading age or grade needed for a person to comprehend the material (or at least the sample), or some defined fraction of it.

This is NOT the same as saying that a certain book is suitable for that grade or age indicated by the estimate: *the book will be too difficult for half of that grade.*

A further problem is that of spurious accuracy when a comparative figure is calculated. The loading factors may well have been justified by rigorous factor analysis, but the number of significant figures is often greater than is justifiable in view of needs of the user or accuracy of the sampling, or, indeed, the input to the original analysis. This point will be referred to in a number of the reviews below.

One point should be made about the reviews. They do NOT give immediate answers to the problem of estimating test readability. They do, however, establish certain general principles, and the present writer had difficulty in locating all of the information. These reviews should make clear the general principles, and save others from making the same search.

1. The Flesch Formula (1948 version)

This seeks to provide a comparative index of reading ease: as with the 1949 version, the higher the index, the more readable is the material analysed. Several samples of 100 words are taken, and the averages of three values are recorded:

wl : the word length, measured in number of syllables per 100 words.
sl : the average sentence length measured in words per sentence.

Reading ease (r.e.) is then calculated as
r.e. = 206.835 - .846 wl - 1.015 sl.

Gilliland (p.91) appears to confuse this with a reading grade. The reader will note that if this were so, the requisite reading grade would *drop* as word length and sentence length increased. In fact a high number indicates ease of reading.

The spurious accuracy implied by six significant figures is avoided in the next method, which also avoids the complicated calculation.

2. The Flesch Formula (1949 revised version).

This version requires that "enough" samples of 100 words are taken to be "fair". Two things are counted: the number of syllables per 100 words (average), and the average number of words per sentence. These are then compared in a table to yield a different reading ease index from the 1948 version. This method avoids a calculation which was unwieldy in pre-calculator days. and avoids the trap for young players engendered by a surfeit of significant figures. This table is reproduced as Appendix 1.

3. The Flesch Formula as revised by Powers, Summer and Kearl (1958)

Several samples of 100 words are taken, as before. The average word length, and the average sentence length are calculated (in syllables and words respectively) and this formula is used:

r.g. = 4.55 wl + 0.0778 sl. - 2.2029

This yields a reading grade: the (American) grade level attained on standardised reading tests.

While the number of significant figures may well have been justified by a factor analysis, little variation would be brought about using r.g. = 4.5 wl. + 0.08 sl. - 2.2, especially when it is recalled that this is merely an estimate to the nearest grade. This variation would certainly be within the range of sampling errors.

4. Flesch's human interest formula.

This involves taking 100-word samples, and tabulating the number of "personal words", these being identified according to a complicated formula. The number of "personal sentences" is also counted, again using a set of rules to identify such sentences. The human interest factor (H.I.) is then calculated by

$$H.I. = 3.635\ pw - .314\ ps$$

Once again there must be some doubt about the numbers of significant numbers. The formula is valuable in that it allows for the need to involve reader motivation in any estimate of readability. This measures a different version from that studied elsewhere: there is no way of combining this measure with others.

5. Dale and Chall (1948)

100-word samples are taken through the book, preferably at every tenth page.

The percentage of words outside Dale's list of "3000 words familiar to American 4th grade children" is calculated and this is called x_1.
The average sentence length in words is calculated and called x_2.

These are then used to calculate Xc_{50}: the reading grade score of a student answering correctly half a series of questions (and thus comprehending half the material ??). This is found by

$$Xc_{50} = .1579x_1 + .0496x_2 + 3.6365$$

This system is unwieldy, in that it requires many samples from a normal sized book, and a high degree of familiarity with Dale's list of 3000 words. This second difficulty is somewhat reduced in the next scheme.

6. The Lorge Formula (1959)

A sample of 5 or 10% of the whole material is taken, and the following are recorded:

The sentence length in words (sl).
The ratio of prepositional phrases to words in the sample (ppr).
The ratio of words not in Dale's 769-word list to total words.

This is referred to in the formula as hwr.
These are then combined to yield a readability index:

$$r.i. = .06\ sl + 9.55\ ppr + 10.43\ hwr + 1.9892$$

Lorge says that this gives a reading grade for a child able to answer 55% of questions "concerning detail, appreciation, import, vocabulary and concept with adequate completeness and correctness".

7. Gunning's "Fog" index (1952)

This is a rather similar approach; samples of 100 words are taken and the average sentence length is calculated. The number of "hard" words (those with three or more syllables) with some exceptions, according to Gilliland, with no exceptions according to McLaughlin, are counted. These two factors are then added together and multiplied by 0.4. This gives the reading grade level required for understanding the material.

8. McLaughlin's SMOG Grading (1969)

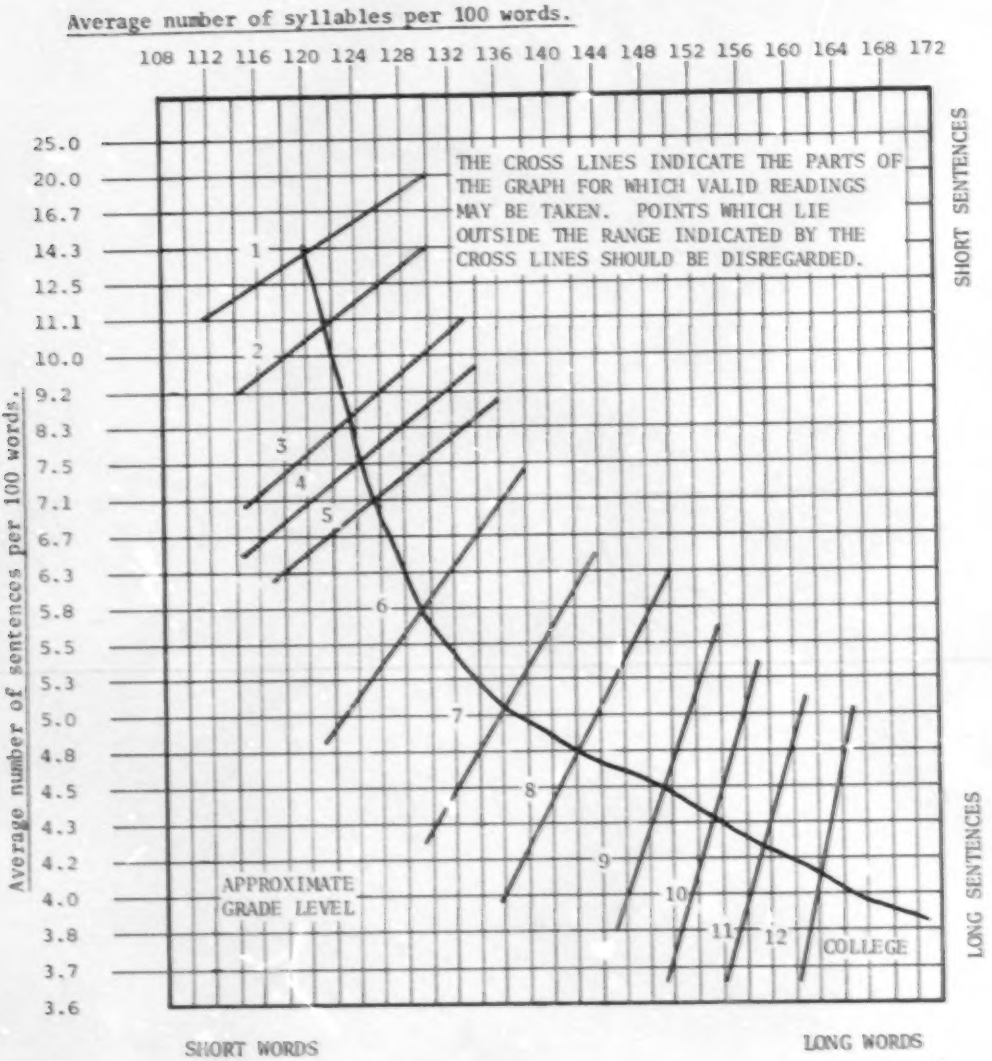
McLaughlin, writing in 1968, rated Dale and Chall as the most accurate followed closely by Flesch (version unspecified), followed closely by the Fog index, which he recommends on the grounds of economy of effort. It is thus significant that he saw fit, the following year, to produce this index. SMOG, says Gilliland, is in honour of Fog, and stands for Simple Measure of Gobbledygook.

Ten sentences are selected at each of the start, the middle, and the end of the text. Count all of the words which are of three or more syllables. Calculate the square root of this total, round down and add three to find the grade a person must have reached to understand fully the text.

9. Fry's graph.

This uses "average number of syllables per 100 words", and "average number of sentences per 100 words" as the variables. The result is given as the "approximate grade level".

This is a reading grade which was developed for use in Uganda, so that the graph may not be immediately applicable in our context. The graph does, however, provide a convenient method for ranking passages in terms of difficulty. Counts should be made on three randomly selected 100-word passages from the book or article under consideration.



READABILITY AND TESTING

It is not possible to use these formulae on test items because the items are usually too short. It is possible, however, to derive certain "rules of thumb" and these are offered here without endorsement.

1. Shorter words are better than long words.
2. Familiar words are better than unfamilar words.
3. Short sentences are better than long sentences.
4. Prepositional phrases should be avoided.
5. Personal words and sentences are to be preferred over the impersonal.
6. The active voice is preferable to the passive voice.

While these rules have a certain *a priori* attraction, it must be admitted that they may not always be sufficient. Consider this item:

> In a valley in lower California, ranchers poisoned off all the coyotes, (animals which usually feed on small rodents) because they took an occasional calf. Since the extermination of the coyotes, the valley, once containing rich grasslands, has become denuded of vegetation and is now a waste land. The most likely factor associated with the disappearance of the coyotes and the denudation of the land is
>
> A. destruction of the vegetation by drought.
> B. clearing of the land for pastures.
> C. decreasing numbers of calves dying.
> D. a large increase in the number of rodents.

The item was written by a teacher and submitted for inclusion in the Science Library of Test Items Item Collection. It was reviewed and extensively rewritten. Finally, it took the form shown on the next page.

The San Diablo Valley in California was a rich farming area where the main "crop" was cattle. There were coyotes in the valley which lived mainly on small rodents (rat-like plant-eating animals). The coyotes also killed and ate the occasional calf, so the ranchers laid baits and destroyed the whole coyote population.

Two years later, there was almost no life left in the San Diablo Valley. "It's just like a waste land" said one rancher. "I guess we've learned our lesson the hard way" said another.

The factor relating the coyote poisoning to the damage to the valley would be the

A. destruction of plant life by drought.
B. clearing of the land for pastures.
C. decreasing number of calves dying.
D. large increase in the number of rodents.

The effect of the rewriting was as follows:

	Percentage Answering				Facility	Discrimination
	A	B	C	D		
Original	13.4	12.9	14.7	59.0	.59	.55
Re-write	10.2	13.1	13.5	63.1	.63	.53

While the difference in facility (4%) does not seem very great, one other question was identical in each of the tests. The facility of that item was .34 in the original test, and .29 in the second test. This could be taken to indicate that the students doing the second test had less "science ability" (whatever that may be), so that the 4% gain is highly significant. The work of Johnstone and Cassels would seem to bear this out. They used items from the Scottish Certificate of Education Examination Item Bank. Items were modified by:

* Altering a single word.
* Reducing the length to diminish "linguistic noise".
* Changing from a negative to a positive form.
* Removing subordinate clauses.

These items were then assembled into tests with alternate original and simplified questions. Each item thus appeared in one test in its hard form, and in another test in its simplified form.

As examples of single-word alteration, Johnstone and Cassels offer this set of examples:

Original Questions	Percentage Correct	Simplified Questions	Percentage Correct
Which one of the following is *not* a pungent gas? A. Sulphur dioxide B. Hydrogen chloride C. Chlorine D. Oxygen	80	Which one of the following is *not* a choking gas? A. Sulphur dioxide B. Hydrogen chloride C. Chlorine D. Oxygen	95
A fused compound conducts electricity. This suggests that the bonding in the compound is A. Covalent. B. Polar Covalent. C. Metallic. D. Ionic.	51	A melted compound conducts electricity. This suggests that the bonding in the compound is A. Covalent. B. Polar Covalent. C. Metallic. D. Ionic.	62
Which one of the following requires a non-aqueous solvent to dissolve it? A. Salt. B. Sugar. C. Sodium nitrate. D. Sulphur.	34	Which one of the following requires a liquid other than water to dissolve it? A. Salt. B. Sugar. C. Sodium nitrate. D. Sulphur.	49

They show as examples of items with a reduced number of words, the following:

Original Questions	Percentage Correct	Simplified Questions	Percentage Correct
Which statement is correct about the ions $^{8}_{3}Li^{+}$ and $^{8}_{4}Be^{2+}$? A. They contain the same number of neutrons. B. Their atoms contain the same number of protons. C. They will combine with the same number of F^{-} ions. D. They contain the same number of electrons.	31	$^{8}_{3}Li^{+}$ and $^{8}_{4}Be^{2+}$ have the same number of: A. Neutrons. B. Protons. C. Charges. D. Electrons.	43

Original Questions	Percentage Correct	Simplified Questions	Percentage Correct
The atomic weight of chlorine is usually quoted as 35.5. It is not a whole number despite the fact that protons and neutrons have very closely integral atomic weights because A. Ions are present. B. Impurities are present. C. Unequal numbers of protons and neutrons are present. D. Isotopes are present.	66	The atomic weight of chlorine is 35.5. Why is it *not* a whole number? A. Ions are present. B. Impurities are present. C. Unequal numbers of protons are present. D. Isotopes are present.	78

And further, an example of positive statements *vice* negative statements:

Original Question	Percentage Correct	Simplified Questions	Percentage Correct
An element has only three isotopes of mass numbers 14,16 and 17. Which one of the following could *not* be the atomic weight of the element? A. 14.2 B. 15.4 C. 16.3 D. 17.1	50	An element has only three isotopes of mass numbers 14, 16 and 17. Which one of the following could be the atomic weight of the element? A. 11.7 B. 13.9 C. 15.1 D. 17.2	62

The obvious question to ask is: why did rewriting work so much better for Johnstone and Cassels than for S.C.D.U.? There are at least four possibilities:

* One item in two tests was too small a sample, and sampling errors hid a real difference.
* Possibly the elements of the rewriting in the S.C.D.U. case confounded each other.
* Possibly students take little notice of the stem, and so were not confused by the "hard" version.
* Possibly the technical terms which were replaced were not as relevant to item difficulty as the one(s) not replaced.

The last possibility may be addressed specifically. The last sentence of the stem is a complex one, involving an understanding of causality, and also uses the term "factor". This is common to the two forms of the question, and the work of Gardner (summarised in Appendix 3) suggests that "factor" is a problem word. A study of Fourth Form Victorian school students in 1970 showed that 24% were unable to select a correct meaning for this word. It seems reasonable to assume that about one quarter of the Year 10 students in this state today have difficulty with the word.

Against this, there is the possibility that questions such as this play an active role in promoting understanding of the meaning of "factor" and other technical link-words. But what will play the part of <u>teaching</u> the Principles of Causality? It seems unlikely that test items would do this in any satisfactory way, although suitable tests may show up a deficiency in this area. Tests may thus help teachers to deal with the problem by teaching to it.

SOME SOLUTIONS

Firstly, there are the "rules of thumb, already mentioned:

1. Shorter words are better than long words.
2. Familiar words are better than unfamiliar words.
3. Short sentences are better than long sentences.
4. Prepositional phrases should be avoided.
5. Personal words and sentences are to be preferred over the impersonal.
6. The active voice is preferable to the passive voice.

Then there is the possibility of questioning the questions. If a question is to test a student's understanding of a principle of ecology, difficult concepts and terms should be avoided as far as possible. In the "coyote" question, the stem would read better if it ended up:

> An expert said that the damage was caused by the poisoning of the coyotes. This would be because of the
>
> A. destruction of plant life by drought.
> B. clearing of the land for pastures.
> C. decreasing number of calves dying.
> D. large increase in the number of rodents.

Thirdly, there is the possibility of presenting questions in some other form. If students have trouble reading, why not give them an oral test? There are several reasons against this: test items may be unecessarily simple, test items tend to become tests of short-term memory (of the question), and students may feel insulted if they are "singled" out for special treatment.

It was this last pcssibility which led Mr. E.R. (Ted) Laybutt of Duval High School to suggest this solution:

1. Test items are hand written on spirit stencils, and run off.
2. The test is given to the students with the teacher apologising for poor legibility and phrasing: "I did this in a hurry".
3. To make amends, the teacher reads the questions and explains the questions. This reduces the test to one of Science knowledge and/or ability, and gives acceptable *science test* results.

A fourth solution would be to seek actively to develop students' skills in processing scientific information. This can be approached from two directions, and is being approached from two directions by the School Certificate Development Unit. The first approach is to produce tests which require written responses from students, and a great deal of work has been prepared in this area. The material will be released at a future date, but a higher priority has been accorded to what will become either the Science Comprehension Testing Programme, or the Science Information Processing Skills Testing Programme. At the time of writing (August, 1979), this programme is almost ready to print. All that remains is for a choice to be made between a title of which sense can be made on the one hand, and an accurate title on the other.

The first release will consist of some 50 or 60 passages of scientific writing, and questions based on those passages, accompanied by some guidance for teachers wishing to construct their own exercises. A number of words will be stressed because Gardner (1972) indicates that these are the words which were understood by less than half of the Form 1 students in his study. While there is no doubt that other words can (and will) be added, the current "stressing" list is:

average	disintegrate	law	regulate
calculate	diversity	liberate	relative
complex	effect	minimum	resist
concept	efficient	negligible	row
conception	emit	neutral	sense
constituent	factor	omit	sequence
continent	fundamental	outline	simultaneous
contribute	grain	partial	spontaneous
converse	illuminate	percentage	stimulate
correspond	immerse	perpendicular	symbol
crest	incident	phenomenon	symmetrical
crude	incline	plot	tank
descendant	initial	probability	topic
devise	invert	recoil	valid
diameter	latitude		

Fifthly, finally, and at the risk of turning this document into a Paul Gardner *festschrift*, Gardner's (1977) report on logical connectives also has important things to say about factors which may determine the readability of a passage.

Logical connectives are those bits and pieces that this writer, for one, always had trouble "parsing". They are useful bits and pieces, serving to connect together propositions. The logical connectives listed below are those which presented severe difficulties to students, with at least one group of Victorian Year 7-10 students showing less than 30% mastery of the connective in one or more contexts (so that we may find only 23% of Year 7 students selecting the correct logical connective to complete a sentence). One of the references in the reading list at the end of this document is from the Australian Science Teachers Journal, and so should be obtainable by most teachers.

The logical connectives which might be termed "particularly nasty" are:

as shown by	hence	moreover	the fact that
as to	here	namely	viz.
by way of	in addition	on the basis of	
clearly	in contrast	only if	where
consequently	in general	respectively	whereas
conversely	in practice	say	whereby
e.g.	in that	similarly	
essentially	including	simultaneously	
for instance	indeed	so also	
further	it follows that	so to speak	

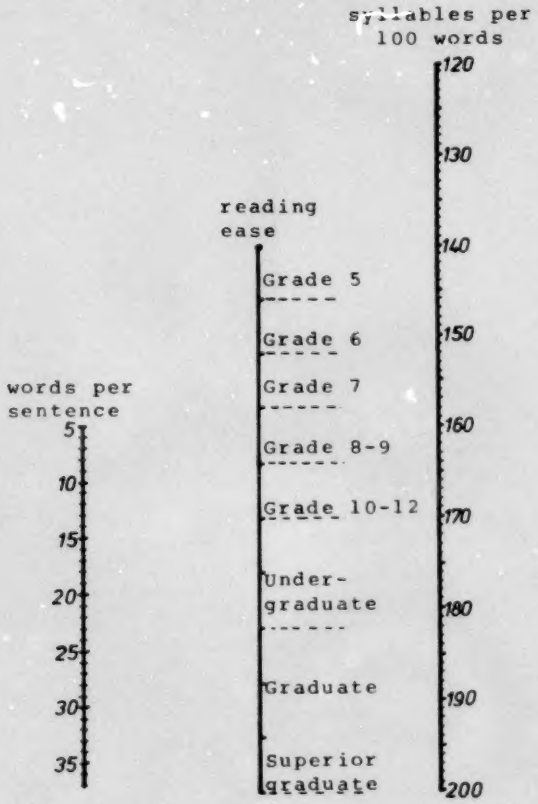
Appendix 1: A Table for measuring reading ease, according to the Flesch Formula

NUMBER OF SYLLABLES PER 100 WORDS

AVERAGE NUMBER OF WORDS PER SENTENCE	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180
5	100	96	92	88	83	79	75	70	66	62	58	54	50	46	42	37	33
6	99	95	91	87	82	78	74	69	65	61	57	53	49	45	41	36	32
7	98	94	90	86	81	77	73	68	64	60	56	52	48	44	40	35	31
8	97	93	89	85	80	76	72	67	63	59	55	51	47	43	39	34	30
9	96	92	88	84	79	75	71	66	62	58	54	50	46	42	38	33	29
10	95	91	87	83	78	74	70	65	61	57	53	49	45	41	37	32	28
11	94	90	86	82	77	73	69	64	60	56	52	48	44	40	36	31	27
12	93	89	85	81	76	72	68	63	59	55	51	47	43	39	35	30	26
13	92	88	84	80	75	71	67	62	58	54	50	46	42	38	34	29	25
14	91	87	83	79	74	70	66	61	57	53	49	45	41	37	33	28	24
15	90	86	82	78	73	69	65	60	56	52	48	44	40	36	32	27	23
16	89	85	81	77	72	68	64	59	55	51	47	43	39	35	31	26	22
17	88	84	80	76	71	67	63	58	54	50	46	42	38	34	30	25	21
18	87	83	79	75	70	66	62	57	53	49	45	41	37	33	29	24	20
19	86	82	78	74	69	65	61	56	52	48	44	40	36	32	28	23	19
20	85	81	77	73	68	64	60	55	51	47	43	39	35	31	27	22	18
21	84	80	76	72	67	63	59	54	50	46	42	38	34	30	26	21	17
22	83	79	75	71	66	62	58	53	49	45	41	37	33	29	25	20	16
23	82	78	74	70	65	61	57	52	48	44	40	36	32	28	24	19	15
24	81	77	73	69	64	60	56	51	47	43	39	35	31	27	23	18	14
25	80	76	72	68	63	59	55	50	46	42	38	34	30	26	22	17	13
26	79	75	71	67	62	58	54	49	45	41	37	33	29	25	21	16	12
27	78	74	70	66	61	57	53	48	44	40	36	32	28	24	20	[illegible]	11
28	77	73	69	65	60	56	52	47	43	39	35	31	27	23	19	[illegible]	10
29	76	72	68	64	59	55	51	46	42	38	34	30	26	22	18	[illegible]	9
30	75	71	67	63	58	54	50	45	41	37	33	29	25	21	17	[illegible]	8
31	74	70	66	62	57	53	49	44	40	36	32	28	24	20	16	[illegible]	7
32	73	69	65	61	56	52	48	43	39	35	31	27	23	19	15	10	6
33	72	68	64	60	55	51	47	42	38	34	30	26	22	18	14	9	5
34	71	67	63	59	54	50	46	41	37	33	29	25	21	17	13	8	4
35	70	66	62	58	53	49	45	40	36	32	28	24	20	16	12	7	3

Appendix 2: A scale for measuring reading ease (adapted from Rudolph Flesch: "The Art of Readable Writing", Harper and Row, 1949).

HOW EASY IS IT TO READ?



Appendix 3: A summary of the findings of Gardner with respect to Victorian pupils' understanding of various 'connecting words' used in science.

The table gives percentages correct for the total sample and for Forms 1-4 separately for the named words in the context indicated (recognition of an instance or synonym, recognition of a diagram, context usage, sentence completion and gap filling as shown below).

I. Verbal Recognition

IA Recognising a Synonym

The bird was audible.

A. It made a noise which could be heard.
B. It was very beautiful to look at.
C. It was a long way from home.
D. It was flying very slowly.

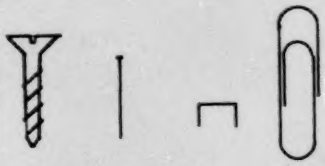
IB Instance Recognition

Which of the following is a sense organ?

A. the brain.
B. the heart.
C. the tongue.
D. the legs.
E. the stomach.

II. Diagram Recognition

Which drawing shows a pin?



(A) (B) (C) (D)

III. Context Usage

Which sentence uses the word convenient correctly?

A. Mary found it convenient to do her housework at night, when the house was quiet.
B. The cook made some soup which tasted very convenient.
C. The books were sold to the children; the books did not cost much so the children were convenient.
D. Bill was sick, but after a week he felt convenient again.

IV. Sentence Completion

When the plant was put inside the jar of gas, its leaves changed from green to yellow. The leaves were:

A. adjusted by the gas.
B. deflected by the gas.
C. displaced by the gas.
D. resisted by the gas.
E. affected by the gas.

From the list of words pick the word that best completes the sentence.

The school held _____ to see which boy could kick a football the longest distance.

A. an argument.
B. a substitution.
C. a competition.
D. an effort.
E. an error.

The material is taken from Gardner, P: "Words in Science", a publication of the Australian Science Education Project, Melbourne, 1972, and is reproduced by permission of the Curriculum Development Centre.

* * * * *

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
ability	82	71	79	88	90	sent.comp. : some chemicals have a. to make plants grow
abnormal	90	85	87	93	95	a.rainfall = unusual
absence	79	74	78	80	85	a.of light = there was no light
absorb	95	91	94	97	99	water a.ed = soaked up
abundant	85	72	82	93	94	a. supply of pears = more than enough
accumulate	77	61	70	87	92	clouds a.d = came together
accurate	84	75	79	88	92	a.description = correct in every detail
action	60	46	57	64	76	sent.comp. = a.of gas on metal
adjacent	86	73	83	95	96	a.seats = next to one another
adjust	72	64	75	77	73	ex.of a.ing a ladder = making it longer by turning screws
adopt	89	88	82	93	92	a. a plan = think it is a good idea
adult	98	97	97	100	98	ex. of a. = 25 year-old
advantage	90	85	89	95	92	a. over others in games = always better
affect	90	87	93	88	91	sent.comp. : leaves change colour = a.ed by gas
agent	83	72	80	87	93	a. in rusting = cause of rusting
agriculture	86	75	82	93	96	a.al research = helps grow better crops
airtight	90	82	87	96	94	a. jar = doesn't let air in
algebra	64	48	58	71	81	sent.comp. : a + 2b = 6 found in book on a.
alternate	82	64	82	91	92	a.d as form captains = one, then the other etc.
analysis	79	68	78	81	92	sent.comp. : a. of rock showed ...
ancestor	89	84	87	91	92	ex. of man's a. = grandfather
angle	88	80	85	93	95	recog. diag. with largest a.
annual	82	70	78	90	90	a. examination = once a year
aperture	77	67	73	83	87	a. = opening
apply	89	83	88	93	94	sent.comp. : truck stops when brakes a.ied
appropriate	81	70	79	91	83	sent.comp. : most a. unit of length
approximate	84	81	79	86	89	a. distance = roughly correct
argument	94	92	92	95	97	sent.comp. : a. over answer to problem
arid	75	53	72	86	92	a. = dry and bare
arithmetic	95	93	95	97	95	a. = working with numbers
artificial	95	90	94	97	98	a. pineapple drink = tastes like pine-apple, but ...
ascend	89	83	88	92	92	balloon a.s = goes up
ash	90	84	90	93	94	a. = grey dust under fire
assemble	96	93	95	98	96	a. = put together (model aeroplane)
assignment	89	80	87	95	94	teacher gave a. = job to do
assist	94	91	93	95	97	Mary a.ed Anne = helped
associate	77	70	78	78	84	malaria a.d. with tropics = often found in tropics
assume	85	76	85	91	87	sent.comp. : mother a.d that book was borrowed
attach	96	90	97	98	98	a.ed paper to window = stuck on
attack	95	93	95	97	95	dog a.ed snake = began to fight
attract	92	87	90	95	96	insects a.ed by light = moved towards
audible	62	45	60	69	75	bird was a. = made noise which could be heard
automatic	85	78	85	88	92	clock strikes a.ally = without help from any person

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
available	96	94	94	97	99	tools a. = can get when needed
average	52	35	54	60	61	recog. a. of three given numbers
avoid	91	89	93	90	94	sent.comp. : driver a.ed hitting tree
aware	92	88	92	93	94	corr.sent.us. : a. of noise
balance	93	91	93	96	94	recog. diag. of two blocks b.ing
balloon	99	99	99	99	100	recog. diag.
basic	93	87	93	96	97	ex. of basic thing = eating
basin	95	93	97	97	94	use of b. = wash hands in it
behave	93	90	91	94	96	sent.comp. : animal b.d. in a funny way
bench	98	97	97	99	98	b. like a table
bend	97	97	95	99	98	recog. diag. of object with b. in it
bind	94	86	95	97	98	b. hands = tie together
blank	97	95	97	99	98	recog. diag. of b. box
bounce	85	79	87	87	89	recog. diag. of ball b.ing
boundary	85	76	84	91	91	recog. b. of school from diag.
brake	97	96	96	97	98	b. on truck = stops it
breed	89	92	86	93	95	b. mosquitoes = grow and multiply
breeze	92	89	93	94	94	b. = light wind
brightness	92	91	94	90	94	sent.comp. : eyes hurt because of sun's b.
brittle	86	75	86	92	94	glass is b. = breaks easily
bubble	96	93	95	100	98	b.s in water = small amounts of air
bud	92	89	91	94	94	recog. b. grows into leaf or flower
bulb	90	84	92	95	91	recog. diag. of plant b.
bump	89	88	86	92	93	ex. of b. = two marbles hit
calculate	84	68	83	92	96	boy c.d volume = found out by arithmetic
camouflage	91	85	88	95	95	c. man in jungle = wear same colour clothing
canal	92	83	93	97	95	c. = tube or passage for liquids
cancel	89	83	91	88	95	recog. ex. of arithmetical c.ling
candle	97	95	98	98	99	recog. diag.
capable	84	76	84	92	85	sent.comp. : dogs c. of biting
capacity	91	82	88	96	97	c. of tank = how much liquid it holds
capture	92	89	92	96	93	c.d gas = caught it and stopped it escaping
caution	91	86	92	92	95	add liquid with c. = carefully
cave	90	81	89	95	94	c. = large hole in ground
centre	97	95	98	96	100	recog. c. of circle from diag.
century	95	90	94	98	98	c. = 100 years
chalk	98	97	99	99	97	use of c. = write on blackboard
characteristic	83	73	79	88	91	eggs had c. smell = unlike any other
chest	98	96	98	99	98	which in c.? = heart
chew	92	88	90	96	95	mouse c.ed paper = tore with teeth
chip	88	82	88	89	93	c. of rock = piece size of fingernail
clamp	90	80	90	95	96	c. used for holding things
classify	93	90	91	96	95	rocks c.ied = put in groups
climate	88	80	89	89	93	c. of Port Moresby = hot and wet
clue	94	91	96	93	96	corr.sent.us. : letter gave police a c.
coarse	85	76	84	92	92	tool was c. = rough
coil	93	89	91	97	96	recog. diag.
coincide	80	60	77	90	93	two things c. = happen at same time
collapse	93	88	94	95	96	building c.d = fell down

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
collection	98	98	97	99	100	rock c. = pieces of different rocks
collide	95	93	95	96	98	bird c.d with tree = flew and hit
column	69	63	63	73	79	recog. c. of numbers in a table
combination	92	86	91	94	97	c. = putting things together
commence	92	86	91	96	95	c. a test = begin
comment	95	90	96	96	99	made a c. = said or wrote something
communicate	95	94	95	94	96	some animals c. = understand sounds made by others
compare	93	89	91	94	98	c. two trees = say how alike
competition	96	96	96	94	99	sent.comp. : football kicking c.
complex	68	52	64	77	82	TV is c. equipment = many parts
complicate	95	94	91	97	98	ex. of c.d job = building a school
component	69	49	63	76	87	c.s of a car = parts of which it is made
composition	70	49	61	81	91	c. of brick = what it was made of
compress	90	83	88	93	95	c. = push together and make smaller
concept	52	32	45	61	74	no c. of cat = no idea of what a cat looks like
conception	53	31	44	63	74	sent.comp. : baby grows after c.
conclusion	85	76	86	88	91	given description of experiment, recog. c. (boiling pt. = 90°)
conical	74	62	72	79	83	recog. diag. of cone
consecutive	78	68	78	81	88	ten c. days = every day for ten days
consist	94	88	93	97	91	cloth c.s of wool and cotton = made of
consistent	81	68	79	87	92	results c. = all about the same
constant	84	71	79	92	96	weight c. = stayed the same
constituent	59	44	51	63	81	c. of a cake = one of things from which made
construct	92	86	93	95	95	c. a school = build it
consume	67	47	62	76	85	bird c.d bread = ate it
contact	93	87	92	97	96	recog. diag. of two rods in c.
container	86	80	84	88	92	which not a c.? = a table
contents	92	87	92	95	96	c. of a jar = water
continent	67	54	64	71	79	Australia a c. because ...
continual	93	89	91	96	94	c. noise = goes on all the time
contract	62	39	59	70	80	metal c.ed = become smaller
contrast	58	51	53	60	58	teacher c.ed trees = said how they were different
contribute	76	58	72	86	89	salt c.s to rusting = one of causes
convenient	92	83	91	97	97	corr.sent.us. : c. to do homework at night
convention	75	61	72	82	85	c. for women to cover faces = usual
converge	75	58	74	81	87	lines c. = get closer together
converse	39	38	39	38	41	c. of a statement : if acid, then litmus red
convert	84	72	84	88	91	c. something = change it into something else
co-operate	94	91	94	96	97	two men c.d = work together
co-ordination	89	81	89	92	94	police and army c.ed = worked well together
cord	92	87	93	94	93	use c. to tie up dog
core	90	85	93	92	90	c. of pineapple = middle part
cork	98	98	97	99	99	recog. from diag.
correspond	49	35	44	58	61	corr.sent.us. : fingers on hand c. to toes

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
crack	98	97	97	98	99	recog. diag. of block with a c. in it
creation	93	88	93	95	98	c. = making something new
crest	66	50	66	72	74	c. of a hill = top
criticise	75	66	72	79	83	sent.comp. : 'drawings good, writing not' = c.ing work
crude	65	42	62	71	87	c. sulphuric acid = not very pure
crush	95	92	97	95	97	c. a cigarette by = standing on it
crust	93	87	92	95	97	c. = hard outside layer
cultivate	86	76	84	92	92	c.d. tomatoes = planted and looked after
cure	86	82	85	88	90	medicine c.d man = made well again
curve	97	96	96	98	98	recog. diag. of a c.d line
damage	94	91	97	96	90	something d.d. = has something wrong with it
damp	95	92	97	96	95	paper d. = a bit wet
decay	81	72	79	83	90	ex. of d. = dead log
decimal	93	89	93	93	95	ex. of d. = 1.2
decrease	91	80	92	96	97	d. wages = less then before
define	85	74	78	90	97	d. a word = say, what it means
definite	95	93	94	96	96	d.), going swimming = sure
deflect	76	64	75	80	83	ex. of ball d.ed = rolls, hits wood, changes direction
degree	78	66	78	84	85	distinguish correct, incorrect use as a unit
demonstrate	94	91	93	96	97	teacher d.d experiment = showed how
dependent	92	85	92	95	99	animal d. on plants = must have plants
depth	89	82	90	90	95	d. of harbour
derive	80	74	73	84	91	sent.comp. : medicine d.d from tree
descend	85	69	85	92	93	d.ed a mountain = climbed down
descendant	48	32	47	52	62	man's d.s = children and granchildren
description	91	84	93	95	92	d. of rock = saying what it looks like
design	97	96	96	97	99	d.ed a house = drew a plan
detect	73	61	71	79	83	sent.comp. : just hear a noise = d. the noise
develop	96	94	95	99	99	seeds d.ed = grew into plants
device	81	67	81	87	88	corr.sent.us. : hammer a d. to knock nails
devise	68	53	65	69	84	d.ing an experiment = thinking about how to do it
diagnose	83	69	79	90	95	d.ing a disease = finding out what it is
diagonal	79	69	75	85	86	recog. diag. containing a d.
diagram	97	94	97	98	99	d. of a fish = drawing
dial	91	88	91	92	93	ex. of something with d. = clock
diameter	70	48	67	81	86	recog. diag. of circle with a d. drawn
dimension	88	77	86	93	95	d.s of a box = length. width and height
disc	87	83	85	92	88	ex. of d. = one cent coin
discuss	92	84	92	95	97	d. something = talk about it
disintegrate	26	18	22	27	38	boiled meat d.s = breaks into pieces
disperse	77	62	74	85	90	gas d.d. = spread out
displace	73	67	72	73	82	liquid d.d. air = pushed out
dissolve	95	90	95	97	99	ex. of d. in water = sugar
distinct	85	71	85	90	95	veins of leaf d. = clearly different
distinguish	96	93	95	97	99	d. two stamps = could tell they were different

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
distribute	88	79	85	91	96	d. chemicals = give them to different people
disturb	88	89	89	87	88	corr.sent.us. : d. bird, sleeping man, bottle on table
diversity	62	49	58	66	78	recog. set of diag. having greatest d.
dominant	71	51	67	81	88	d. = stronger than
doubt	90	82	91	94	95	d. = don't really believe
doubtful	93	90	94	97	90	d. about swimming in race = did not know if in it or not
drain	91	87	90	93	94	ex. of d.ing something = sink of water
drought	90	85	88	95	93	d. occurs=no rain for long time
duplicate	94	89	93	98	96	d. notes = make a copy of
edible	86	77	85	91	93	coconuts e. = can be eaten
effect	56	45	46	62	70	sent.comp. = heat is an e. of electricity
efficient	61	48	56	68	72	corr.sent.us. : large brooms more e. for sweeping
effort	94	93	94	94	94	sent.comp. : made e. and got better
elastic	83	74	86	86	86	sent.comp. : string described, is e.
emit	62	46	58	65	79	recog. diag. of star e.ting radio waves
enable	76	62	76	83	83	corr.sent.us. : aeroplane e.d man to reach town
enlarge	95	93	93	96	97	picture e.d = made bigger
equipment	93	89	93	95	96	school boy's e. = pen, pencils, ruler
equivalent	92	88	92	93	97	Australian, N.Z. dollar e. = the same as
erect	86	75	85	91	93	recog. diag. of e. flower
error	94	92	93	95	97	recog. ex. of arithmetical e.
essential	75	63	71	82	86	sodium e. to life = must have sodium
estimate	81	76	76	82	89	e.ing length of string = guessing
evacuate	87	78	85	94	93	e. a glass jar = empty it completely
exception	89	79	87	93	96	all boys with good results, with the e of ..
excess	83	70	79	90	94	builder has e. wood = more than needed
excite	79	69	77	80	89	muscle e.d = made to move quickly
exclude	83	68	79	91	95	e. water = not allow water in
exert	77	64	68	88	87	sent.comp. : pushing a car = e.ing a force
expand	92	89	91	93	96	metal e.ed = became bigger
expel	84	77	82	87	93	e. a gas = push it out
experience	92	88	93	92	97	my e.s = what has happened to me
explode	90	86	88	93	94	chemicals e.d = loud noise, broke beaker
expose	81	70	76	89	90	paper e.d. to light = light reached it
exterior	94	91	92	97	96	e. of house = outside
external	73	53	68	82	90	e.skeleton = outside
extinguish	94	93	93	96	96	e. a fire = put it out
extra	90	87	88	93	91	insect with e. leg = seven instead of six
extract	95	93	97	96	96	e.ed oil from leaf = took it out
extreme	88	79	88	92	93	sent.comp. = temperature of 120° is e.
factor	58	36	52	67	76	sent.comp. : drinking drivers one f. in causes of accidents
feather	97	96	97	98	96	which covered with f.s? = bird
female	98	97	98	99	98	ex. of f. = mother
film	97	95	98	97	98	f. in camera = roll of paper in back
film	74	64	72	75	84	recog. diag. of f. of oil on water
fin	79	82	79	81	75	recog. from diag. of fish

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
flexible	95	93	95	95	96	f. = bend without breaking
float	95	93	97	95	97	block f.s = stays on top of water
fog	75	66	79	75	81	f. in a jar = thick gas
formation	93	88	93	96	96	f. of rocks = how made and put together
frog	99	99	99	99	99	recog. diag. of f.
function	93	88	94	96	95	f. of stomach = work it does
fundamental	67	53	66	73	75	f. laws of physics = most important
gap	95	92	95	97	95	g. in clouds = space between
generate	80	76	81	86	87	machine g.s steam = produces steam for use
globe	91	88	91	91	95	ex. of g. = ball
grain	38	31	35	39	48	g. of rock = how big the pieces in it are
grind	86	79	85	89	90	to g. corn = rub it between stones
hatch	85	82	86	84	87	h. an egg = keep warm until chicken comes out
hook	97	97	98	98	97	recog. diag.
horizon	91	85	91	92	95	sun on h. = when it rises and sets
hygiene	93	88	92	97	98	h. = how to keep clean and healthy
identical	90	85	87	94	94	ex. of i. = two nails made by same machine
identify	90	82	90	93	95	i. a leaf = tell which tree it is from
ignore	96	92	95	97	98	i.d what was said = did not listen to it
illuminate	73	49	71	84	89	i.ion = light
illustrate	65	56	59	70	76	sent.comp. : 6 + 3 is an i.ion of the rule...
imagination	85	78	82	88	91	sent.comp. : boy thinks of new ideas etc. has = i.
immerse	69	52	62	80	85	i. an object = cover with liquid
impact	79	66	77	85	87	ex. of i. = truck crashing into tree
incident	53	42	54	54	62	light i. on metal = hit the metal
incline	54	47	47	61	63	recog. diag. of i.
index	83	78	84	81	89	recog. given extract of book as i.
indicate	92	85	91	94	96	sent.comp. : colour i.d. water there
industry	93	87	93	97	96	i.ial town = one with factories
infinite	95	92	94	94	98	i. list of numbers = goes on for ever
inflate	82	77	83	85	83	i. a ball = blow air into it
influence	76	63	73	79	90	sent.comp. : i. of magnet on nail
information	97	95	98	99	98	ex. of giving i. = man on radio reading news
inhabit	89	84	84	91	95	i. a forest = live in it
inhale	93	88	94	96	96	i. smoke = breathe it in
initial	47	35	45	47	64	i. step of experiment = thing done first
inject	94	91	93	97	96	doctor i.ed medicine = use of needle
injure	94	91	93	97	96	i. hand = hurt it
inquiry	92	86	92	93	97	making i. = asking questions
insert	92	88	90	95	93	i. something = put it inside something else
instant	93	91	93	94	95	do something i.ly = as soon as asked
instantaneous	87	77	84	92	96	i. reaction = very quick
instrument	91	88	88	94	94	recog. that book is not an ex. of i.
intake	82	71	82	85	92	sent.comp. : 6 pints is large i. of water
intelligence	90	89	89	91	94	dog is i.t = learned to do many things
interfere	93	91	93	95	94	storm i.d with plant growth = slow down or stop
internal	88	79	86	93	94	ex. of i. part of body = heart, stomach, bones
interpret	71	56	67	77	83	i. results = explain the meaning

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
intersect	94	89	94	98	95	recog. diag. in which lines i.
interval	94	88	96	96	97	corr.sent.us. : five minute i. between races
introduce	96	94	95	97	98	i. class to science = first lesson in science
invent	90	89	88	95	91	i. a machine = first person to think of it
invert	61	45	54	68	79	i. a beaker = turn upside down
investigate	97	96	98	98	98	people making i.ion = trying to find out things
involuntary	82	67	80	89	92	i. movement of leg = could not control it
irritate	80	69	77	89	86	sent.comp. : smoke i.d eyes
isolate	82	63	77	90	97	recog. diag.
jar	98	98	98	98	99	recog. diag.
jar	96	94	96	98	98	recog. from diag.
juice	98	98	95	99	98	tomato j. = liquid of tomato
junction	82	74	78	87	92	recog. diag. of j. of two lines
kit	94	90	92	96	96	tool k. = set of different tools
label	95	95	93	96	98	recog. l. of bottle from diag.
laboratory	94	91	94	97	96	l. = place where experiments done
latitude	45	35	45	47	52	recog. that two points on diag. of earth have different l.s
law	60	39	5	72	78	recog. ex. of scientific l.
layer	87	77	83	95	95	recog. diag. of something displaying l.s.
leaf	88	86	88	87	91	gold l. = thin sheet
leak	91	87	86	94	95	l. in tank of water = hole
level	96	95	96	96	97	l. piece of ground = flat
level	85	79	84	91	87	given diag., recog. that two surfaces at same l.
liberate	75	54	71	86	90	gas l.d = given off
lightening	93	92	91	96	94	l. when = there is a storm
limit	82	69	81	86	91	speed l. 40 mph = not more than 40 mph
linear	66	52	59	77	80	recog. diag. of l. graph
liquid	95	95	93	97	97	recog. milk as ex. of l.
locate	94	93	93	96	96	l. a house = find
logic	71	61	69	70	78	sent.comp. : l.al thinking
lubricate	59	37	45	70	84	l.s an engine = puts oil in
magnitude	72	50	74	85	80	m. of a. tree = how big it is
majority	91	86	88	96	95	m. of people voted = more than half
male	95	93	95	97	96	recog. father as ex. of m.
manufacture	84	74	82	91	91	recog. that wood is not m.d
margin	92	87	92	94	96	piece of metal with extra m. = slightly larger piece
match	93	91	94	94	94	sent.comp. : socks and tie m.ed well
mate	90	84	90	92	95	m. for male rat = female rat
mathematics	96	95	96	99	97	m. = study of space and number
mature	85	74	82	92	92	ex. of m. = 30 year old man
maximum	77	63	74	84	90	m. temperature 75° = not above 75°
measure	88	87	88	88	89	sent.comp. : m.d length of a table
medium	90	87	90	89	94	given information, identify m.sized packet of cigarettes
method	90	82	87	95	95	m. of experiment = way to do it
migrate	94	90	93	94	98	m.s to Australia = makes it new home
mild	85	75	85	90	89	m. reaction = not very much happened

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
milk	95	93	96	93	96	recog. m. as ex. of something people drink
minimum	70	52	67	82	81	m. temperature yesterday 75° = fell 75°, but not below
minus	91	90	86	91	95	6 m.2 = 4
mirror	98	97	98	98	98	use m. = look at face
mobile	92	87	90	96	97	ex. of m. = bicycle
model	95	95	92	95	97	m. of aeroplane = looks real, only smaller
modify	70	57	61	76	87	m. an aeroplane = make changes to it
moisture	91	89	89	94	94	soil contains m. = water
molten	79	64	75	86	92	iron m. = hot and liquid
mud	93	94	91	96	93	m. = soil and water
multiple	79	70	72	85	90	m. car smash = more than two cars
multiply	91	86	89	94	97	kangaroos m. = more and more of them
naked	72	65	68	75	80	n. flame = not covered
narrow	96	95	94	96	97	recog. diag. of n.est container
needle	97	99	98	98	94	recog. that n. is thin and sharp
negative	62	39	61	73	77	n. temperature = colder than 0°C
neglect	88	78	86	95	92	n. weight of metal = take no notice of
negligible	61	52	68	62	73	rainfall n. = very little rain
neutral	70	53	67	78	82	petrol is n. = not acid, not alkaline
normal	93	91	92	96	95	n.ly goes to school = usually goes
nought	97	97	95	98	98	recog. 6 - 6 = n.
nourishment	96	94	97	98	93	people need n. = enough to eat and drink
obey	97	97	98	99	94	dog o.ed = did as he was told
observation	82	74	77	92	88	sent.comp. : what was seen in an experiment = o.
obvious	77	67	73	83	84	ex. of something o. = sun rises every day
occasional	93	89	93	98	92	o. noise = sometimes
occupy	94	91	94	98	94	gas o.ied jar = took up all the space
occur	87	84	83	90	93	malaria o.s in tropics = happens
odd	93	94	91	98	91	results o. = unusual
odour	93	92	93	96	93	o. = smell
omit	64	42	59	74	81	o.ted to put water in = did not put water in
onion	99	99	98	98	99	recog. diag.
operate	91	88	92	95	90	o. a machine = switch it on and make it go
opinion	89	83	87	83	92	sent.comp. : "which do you like better?" = asking o.
oppose	76	68	71	84	82	recognize diagram of forces o.ing each other
origin	79	64	78	87	87	o. of life = how life first began
outlet	92	88	91	94	97	recog. o. of tank of water from diag.
outline	71	56	70	80	80	o. a problem = tell quickly what problem is
oval	97	97	96	97	97	recog. diag.
overcome	90	85	92	95	90	o. in fight = was stronger
overhead	89	88	91	90	88	ex. of someth[illegible] o. = aeroplane high in sky
parallel	94	91	94	98	92	recog. diag. of p. lines
partial	54	39	51	59	68	sent.comp. : explanation of failure at exam
particle	87	82	84	94	86	p. of glass = very small piece
partner	95	94	95	98	93	p. in experiment = someone to work with
pattern	92	87	90	97	95	recog. diag. of o's and x's arranged in a p.
pea	96	96	97	98	93	recog. that p. is greenand round
peak	96	94	94	98	97	recog. p. of mountain from diagram
pencil	97	97	98	98	94	recog. that p. used to write with

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
penetrate	86	76	84	91	94	spear p.d leg = went into leg
per	88	88	86	88	91	recog. that "births/year" is read "births per year"
percentage	49	41	51	49	55	half written as p. = 50
permanent	84	76	84	89	90	colour changed p.ly = stayed, not changed back
perpendicular	70	47	67	84	81	recog. diag. of p. lines
pest	95	96	96	96	93	recog. that farmer would try to kill p.
phenomenon	67	56	59	73	81	sent.comp. : ... this p. is called an eclipse
pierce	91	87	90	95	91	p.d a tin = made a hole in it
pin	97	97	97	95	100	recog. diag.
pivot	88	82	87	91	92	recog. p. of seesaw from diag.
plot	80	55	81	90	95	teacher p.ted graph = marked in points, connected them
plug	97	94	97	97	98	use of p. = stop liquid running out
plus	98	98	96	99	100	recog. 6 p. 2 = 8
poison	99	99	98	99	100	if man drinks p. = die
pond	98	97	98	98	99	p. in garden = put fish in it
positive	73	64	72	78	81	test for malaria p. = has malaria
positive	78	42	86	92	92	recog. + 3 as ex. of p. number
practise	92	87	91	98	93	boy p.d using a machine : to learn to use it better
precaution	92	88	90	95	95	list of p.s = things to be careful about
precise	95	91	96	97	96	recog. ex. of p. measurement
predict	85	71	85	93	94	p. something = say something will happen later
preparation	79	74	78	85	82	p. for an experiment = getting the materials
presence	85	74	84	92	92	p. of salt in water = there was salt in the water
preserve	94	93	92	96	96	meat p.d. = kept for long time
previous	77	64	72	84	89	p. day = day before
primary	73	63	71	76	83	p. cause of death = recog. from given information
primitive	76	67	65	86	86	sent.comp. : aeroplanes were once p.
probability	63	52	58	68	76	recog. event with highest p.
procedure	89	81	88	94	94	p. of experiment = how to do it
process	79	66	76	84	91	sent.comp. : plants make food; p. uses water
profile	81	67	81	88	90	recog. diag. of p. of man's head
proof	85	77	87	87	90	p. = show that statement is true
propagate	69	67	69	70	71	sound p.d = carried along
propel	89	84	90	90	93	fish p.s itself by tail = uses tail to move through water
proportion	71	65	67	74	81	given data, recog. p. of water in body
pump	80	69	81	88	84	use of p. = move liquid
purify	89	81	92	92	93	liquid p.ied = made clean
rainbow	95	94	96	95	96	recog. diag.
random	25	12	18	36	35	recog. ex. of r. motion = fly flying inside a box
rapid	94	93	94	96	95	car travelled r.ly = very quickly
rare	94	91	94	96	95	r. animal = not many of that kind
rat	97	96	97	98	98	recog. diag.
rate	41	25	39	47	58	given data, recog. death r. in a village
recoil	65	52	63	71	75	snake r.ed = moved back quickly
reference	80	67	77	85	93	r. = name of book on the topic

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
refine	84	76	84	88	90	r.ing sugar = change into clean, white sugar
reflect	70	62	62	79	80	recog. diag. of light being r.ed
refrigerator	98	97	99	98	99	use of r. = keep things cold
regular	76	69	76	76	85	sent.comp. : church bell rings r.ly.
regulate	67	50	61	75	82	corr.sent.us. : accelerator r.s speed of car
reject	93	89	93	96	97	people r.ed money = would not take
relationship	89	79	89	92	94	corr.sent.us. : r. between smoking and illness
relative	60	41	58	68	74	diag., and sent.comp. : Ben is small, r. to Charles
relevant	78	66	75	84	88	distinguish r. from irr. statements about car accidents
reliable	92	88	91	94	95	measurements r. = made carefully
repel	75	58	71	83	88	wire r.led by metal rod = pushed away
replace	93	88	94	94	95	Joe r.d Bill in race = ran instad of
represent	75	59	74	83	86	Mr. J. r.d Bill at meeting = went in place of
research	93	86	94	96	96	r. in motor car factory = trying to find new things
residue	70	57	65	79	81	recog. r. (salt) in a process described
resist	73	55	72	79	90	air r.ed movement of balloon = tried to stop
resource	78	64	76	86	86	r.s of school for teaching = things teacher can use
respond	82	72	80	87	90	sent.comp. : insect r.ing to the light
retard	80	62	80	87	90	chemicals r. growth = slow down
reverse	95	91	96	98	97	r. a car = go backwards
revolve	95	90	95	98	97	insect r.d around light = flew in circles
right angle	91	86	89	95	96	recog. diag.
rigid	74	60	68	82	85	recog. that iron bar is r.
rim	88	81	86	94	92	recog. r. of cup from diag.
ripe	95	95	94	96	95	r. banana = ready to eat
ripple	92	90	88	95	93	r. in water = little waves
rod	95	91	95	97	95	recog. diag.
root	98	96	98	99	99	recog. r. from diag. of plant
rot	96	92	96	98	98	apple r.s = goes soft and smells bad
rotate	90	83	91	95	93	recog. wheel of car as ex. of r.
row	53	53	49	55	57	recog. r. of numbers in a table
rub	83	71	83	90	88	recog. that piece of iron could be r. bed with wool
rubber	95	93	96	96	97	recog. uses of r.
rule	83	78	84	83	88	sent.comp. "Don't put water into acid" = r.
ruler	97	95	97	98	97	r. used to measure length
sample	96	92	98	98	95	s. of rocks = get some small pieces
scale	87	76	85	95	94	recog. s. of instrument from diag.
scent	98	96	98	98	98	flower s. = smell
scientist	95	94	95	96	94	s. person who = does experiments, finds out whey things happen
scratch	91	99	99	95	93	to s. wood, use pin
screen	89	87	89	90	92	recog. s. from diag.
screw	97	96	97	98	98	recog. diag.
sea weed	91	88	92	93	94	s. = plant growing in sea
section	72	61	65	76	86	to get s. of leaf = slice with razor blade
select	93	88	92	96	96	s. a book = pick out a certain book
semicircle	90	85	89	93	93	recog. diag.

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
sense	58	47	53	65	68	ex. of s. organ = tongue
sensitive	74	64	68	83	82	paper s. to light = changes in light
sensitive	82	75	79	86	88	beam balance s. instrument = can weigh small things
sequence	65	57	63	63	80	ex. of 1,2,3,4 in different s. = 2,3,1,4
separate	94	93	93	96	96	to s. salt and sand = put in different places
shallow	88	83	86	91	93	recog. diag. of s.est container
shelf	97	97	97	97	97	use s. = put bottles etc. on
shell	94	92	94	97	96	s. of egg = outside coating
shift	94	93	94	95	95	s. a car = move it
shrink	95	96	94	94	97	sock s.s = gets smaller
sign	87	79	87	90	92	sent.comp. : + and - are positive and negative s.s
signal	93	91	94	94	94	recog. situation in which people are making s.s
significant	89	83	86	93	94	given data, recog. most s. cause of car accidents
similar	95	94	94	96	97	my house is s. to yours = looks like yours
simplify	86	78	86	91	91	s. a problem = make it easier
simultaneous	67	54	66	71	77	two things happen s.ly = at the same time
sink	89	86	91	91	88	recog. diag. of block s.ing
skill	95	90	96	98	95	s.ed in cooking = cooks very well
slide	98	98	99	97	98	recog. diag. of something s.ing
slip	97	96	98	97	99	animal s.ped out of hands = could not hold onto
slit	96	96	97	96	97	recog. diag. of paper with s. in it
slope	95	92	96	96	98	recog. s. of hill from diag.
smash	98	98	99	97	97	s. a house = break into pieces
smear	84	74	80	89	93	ex. of s.ing paint = put drop on window and rub
smell	98	98	99	97	99	to s. something use = nose
soak	97	94	97	97	98	s. block of wood = put in water
soap	99	98	100	98	99	use s. to wash yourself
solve	95	93	92	96	97	s. a problem = find the answer
sour	96	93	96	97	97	ex. of s. = lemon
source	89	79	89	94	94	recog. s. of light from diag.
spark	92	88	91	95	94	recog. that s.s jump from a fire
spill	92	91	93	92	94	s. water = knock over, water runs out
spin	97	97	96	99	97	s.ning = turning round and round
spiral	84	76	82	89	89	recog. diag.
splint	90	87	90	92	92	s. of wood = long, thin, straight
spontaneous	31	15	26	39	45	s. burning = starts without being set alight
spoon	98	98	98	98	99	recog. diag.
spring	97	96	97	97	98	recog. diag. of helical s.
spring	94	89	92	98	96	s. time = between winter, summer
stable	92	85	93	95	94	temperature s. = not changing
stagnant	74	63	69	79	87	water s. = not moving, going bad
stain	80	64	81	86	90	s. cells = colour them
stalk	93	92	92	93	96	recog. from diag. of plant
standard	60	41	50	72	76	sent.comp. : 1 yard metal bar = s. of length
starve	95	91	98	96	97	s. if = not enough to eat

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
stationary	92	85	93	95	95	car s. = not moving
steady	91	87	93	91	94	s. speed = not changing
steam	96	94	96	95	97	s. made when = water boiled
steep	84	82	80	84	89	recog. diag. of s.est hill
stem	96	93	98	98	97	recog. from diag. of plant
stimulate	55	43	48	57	71	medicine s.d the heart = beat faster, more strongly
sting	91	86	90	95	94	sent.comp. : insect biting hand can s.
structure	93	88	92	97	96	s. of a house = parts and how put together
submerge	78	70	76	82	85	diver s.d in water = went down into water
substance	92	87	96	94	94	recog. ex. of s. = petrol
substitute	79	64	76	87	88	s. hydrochloric acid = use it instead of another
subtract	96	93	95	99	95	s. 2 from 10 = 8
successive	89	79	88	93	96	ex. of s. days = Tuesday, Wednesday, Thursday
suckle	73	63	69	81	78	cat s.s kittens = feeds them from her body
summary	91	85	89	95	98	s. of story = most important things
survive	96	94	98	98	97	animal s.d = stayed alive
suspend	76	62	72	84	87	recog. diag. of s.ed ball
sweat	95	92	96	97	96	if man s.ing = skin wet
switch	96	94	97	97	98	recog. s. on diag. of radio
symbol	75	54	73	84	91	recog. s. for oxygen
symmetrical	41	23	35	48	60	recog. ex. of s. figure
system	79	70	77	85	84	sent.comp. : water movement s. in trees
systematic	89	78	93	94	93	boat built s.ally = followed a plan
table	89	80	88	95	95	recog. ex. of a t. of numbers
tabulate	79	75	78	89	93	results of experiment t.d = written down on list
tank	55	43	56	56	65	recog. diag. of t. of water
tape	97	96	97	99	97	recog. diag. of paper t.
target	95	94	95	96	95	ball thrown at wall, t. = wall
technical	96	95	96	97	97	recog. ex. of t. work = make car parts
temporary	77	66	73	80	90	t. building = to be used for short time
tend	89	82	87	94	94	t. to be fat = usually fat
tension	83	75	78	87	93	wire under t. = pulled very tightly
test	94	90	95	96	95	t. a rock for copper = find out if copper in it
textbook	65	55	63	66	80	use of t. = to read and study
theory	74	67	78	78	74	sent.comp. : doctor's idea about a disease = t.
thirst	94	92	94	97	94	to stop t. = get a drink
thrust	79	69	77	83	88	t. of engine = push
thumb	95	95	94	97	96	recog. from diag.
thunder	83	82	86	84	81	sent.comp. : loud noise after flash of light in sky = t.
tide	85	77	82	92	90	t. = rise and fall of sea
tight	98	97	97	98	99	recog. diag. of box with t. string
tilt	95	91	95	96	98	recog. diag. of t.ed tree
toe	96	96	95	95	97	recog. from diag.
tooth	97	98	96	98	97	recog. from diag.
topic	58	48	59	61	66	sent.comp. : light, oxygen, force = t.s
torch	96	95	96	97	97	recog. diag. of flashlight
trace	90	85	90	91	92	t. of copper in soil = small amount

WORD	PERCENTAGE CORRECT					CONTEXT
	Total	*Form 1*	*Form 2*	*Form 3*	*Form 4*	
transfer	97	95	96	96	99	t. something = move it from one place to
transform	85	78	85	91	88	iron atoms t.ed = changed into something else
transmit	90	85	84	95	96	disease t.ted = passed on from one person to another
transport	95	93	96	96	96	t. something = carry it from one place to another
tray	97	98	97	98	97	recog. diag.
treatment	77	67	75	79	86	t. of plants in an experiment = what was done to them
triangle	98	97	98	99	100	recog. diag.
trolley	94	91	94	95	97	recog. diag.
tropic	83	74	85	84	88	recog. part of Earth in the t.s from diag.
trough	89	85	86	91	95	use of t. = fill with water
trunk	96	94	98	96	98	recog. t. of tree from diag.
tube	85	77	83	91	90	recog. from diag.
tunnel	96	95	95	98	97	t. in mountain = large hole through mountain
tweezers	86	81	81	92	93	recog. diag.
twin	96	94	97	94	98	t. engines = two, both the same
twist	96	94	97	96	96	t. a lid = turn it
typical	88	77	87	93	97	t. plants = like others in that place
tyre	96	93	95	96	99	recog. diag.
underneath	96	95	96	98	97	recog. diag. of ball u. table
uniform	86	73	87	87	96	u. speed = same speed all the time
unique	82	70	82	87	90	something u. = only one of its kind
upright	94	90	93	97	96	recog. diag. of u. line
upset	92	85	94	94	96	u. a glass of water = knock it over
valid	55	30	50	65	79	said something v. = correct
variable	90	80	90	93	96	v. weather = changing
variety	93	87	93	96	97	v. of fruit = different kinds of fruit
vehicle	96	93	97	95	99	ex. of v. = motor car
vertical	76	64	72	84	87	recog. v. line from diag.
vessel	73	56	70	78	90	if farmer had v. = could put water in it
vibrate	86	80	83	91	91	hand v.ing = moving backwards and forwards quickly
vigorous	88	82	84	92	93	ex. of v. activity = running fast
violent	91	84	89	96	96	ex. of v. reaction = petrol exploding
violet	80	69	79	85	90	v. medicine = purple
visible	94	92	92	96	98	stars v. = able to be seen
vision	95	92	94	96	98	boy's v. good = can see well
vital	78	61	75	85	91	some gases v. to plants = very important
vocal	84	71	83	91	94	man was v. = talked a lot
web	98	96	97	98	100	recog. diag.
wedge	82	75	78	89	85	recog. diag. of w.-shaped object
weed	87	80	86	91	90	w.s = plants which grow wild and are not wante
wilt	85	78	82	90	90	recog. diag. of w.ed flower
wipe	95	92	95	95	97	w. table = rub with cloth
zero	96	94	96	96	98	recog. from diag. of number scale

REFERENCES AND FURTHER READING

Flesch, Rudolph, *The Art of Readable Writing*, New York: Harper and Row, 1949.

Gardner, Paul, *Words in Science*, Melbourne: Australian Science Education Project, 1972 (out of print).

Gardner, Paul L., Difficulties with Illative Connectives in Science amongst Secondary School Students. *The Australian Science Teachers Journal*, 1978, 24, 23-30.

Gardner, P.L., Logical connectives in science: a preliminary report *Research in science education*, 1975, 5, 161-176.

Gardner, P.L., Schafe, L., Myint Thein, U, and Watterson, R., Logical connectives in science: Some preliminary findings. *Research in science education*, 1976, 6, 97-108.

Gardner, P.L., *Logical connectives in science*. Report to the Education Research and Development Committee. 1977. (This document is virtually unobtainable.)

Gardner, P.L., Logical connectives in science: a summary of the findings. *Research in science education*, 1977, 7, 9-24.

Gilliland, John, *Readability* London: University of London Press, 1972.

Johnson, R.K. Readability. *School Science Review*, 1979, 60, 563-568. (Contains some useful references.)

Johnstone, A. and Cassels, J., What's in a word? *New Scientist*, 1978, 78, 432-434.

Lorge, Irving. The Lorge formula for estimating difficulty of reading materials. New York: Columbia University Teachers' College Press, 1959.

Pumfrey, Peter D., *Reading: tests and assessment techniques*. London: University of London Press, 1976.

FOR THE VERY BRAVE:

Taylor, Insup. *Introduction to Psycholinguistics*. New York: Holt, Rinehart & Winston, 1976. (Contains a good discussion of Yngve's paper.)

Yngve, V.H., A model and an hypothesis for language structure. *Proceedings of the American Philosophical Society*, 1960, 104(5), 444-466. (This journal is held by the Royal Society of N.S.W. Library.)